

High Performance Computing for CAE simulation

Bosung Lee CPO (Chief Product Officer) NEXTFOAM

Need for high performance computing in CAE simulation

• Massive computational resources

- Parallel processing speeds up calculations significantly by enhanced computational power

• Handling larger data sets and intricate geometries

- Manages more parameters for advanced modeling and increased simulation complexity

• Simulates finer details for improved accuracy and resolution

- Crucial for predicting real-world behaviors in simulations

• Accelerates multiple iterations within shorter timeframes to reduce time to solution

- Enables quicker design decisions and model refinement.

• Scalability and flexibility for growing computational requirements

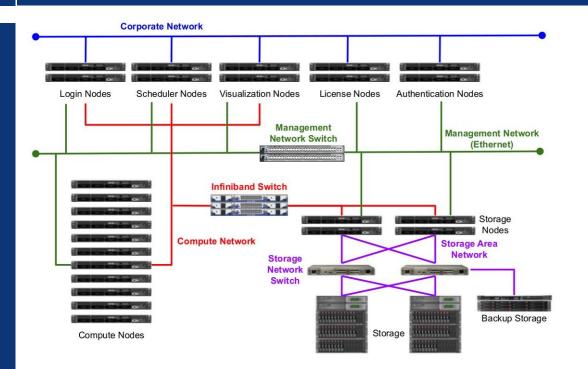
- Adapts to varying project demands, from small tasks to large simulations.

• Enabling Advanced Algorithms to support complex solvers and algorithms

- Allows for advanced methods like multi-scale modeling and machine learning



On-premise HPC architecture and simulation workflow



- User / Management Server
 - Login nodes : user login & jub submission
 - Scheduler nodes : scheduling HPC jobs (LSF / PBS / Slurm)
 - Visualization nodes : pre & post processing with GPGPU
 - License & Authentication nodes : manage licenses and user auth
- Compute nodes with high performance processors and memory
- Management network to manage and monitor the HPC
- Compute network to handle MPI & File I/O communication
- Storage systems
 - Shared storage for scratch data and permanent simulation data

If the job fails, restart from the preparation step

Preparation

- meshing and preparing job scripts
- requires large local infra for large case

Job

- login to HPC and upload input files
- text-based and requires high speed network

Transfer inputs

- Job submission
- jobs are queued until resources are available
- longer waiting time on limited resources

Job execution

- when resources are available, jobs are executed
- monitoring is performed text-based

Post processing

- download results to local workstation with long transfer time
- limited visualization nodes



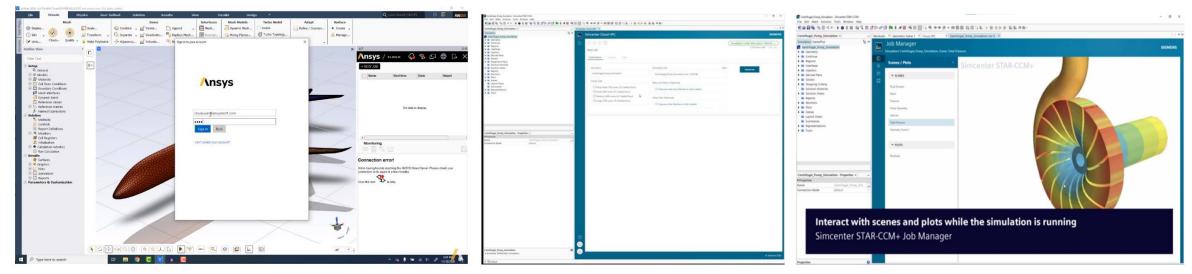
Challenges in HPC: Adapting to Evolving Simulation workflows

• GUI-based interactive simulation workflows

- Enhancement of desktop and workstation performance drives the interactive simulation workflows

• Growing demand for seamless integration of IT-based environments, including HPC cloud

- Ansys Cloud on Azure / Siemens Simcenter Cloud HPC
 - Run pre- and post-processing on the local desktop and simulations on the cloud HPC environment



Ansys Cloud on Azure

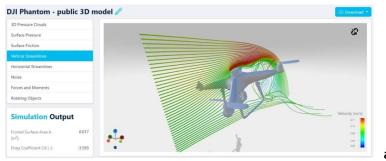
Siemens Simcenter Cloud HPC



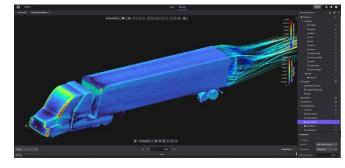
Challenges in HPC: Adapting to Evolving Simulation Workflows

Advancement of web-based simulation SaaS services

- Upload the simulation geometry and conditions to the service, and the entire simulation is performed in the cloud



airshaper.com



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luminarycloud.com
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Cloud based HPC services

- Provide HPC clusters with pre-installed software and perform simulations via a scheduler like traditional HPC in the cloud

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AWS ParallelCluster



Next Generation HPC for CAE simulation

• Limitations of traditional and current newly introduced HPC architecture

ŀ	IPC architectures	Features and limitations
	On-premise HPC	 Long setup time, management overhead and inflexible response to simulation workload and long job queueing Non-interactive simulation based on batch job scheduler and Frequent data transfer for pre and post processing
(Cloud integration of application	 Seamless integration of interactive applications Dependency on specific applications and Cloud services, Lack of support for various simulation applications
	Web-based simulation SaaS	 Limited to provided simulation workflows Challenges in addressing diverse analysis problems
	Cloud based HPC service	 Flexible setup and load response, but non-interactive workflow based on batch processing similar to on-premise HPC Limited to the workflows and software provided by the service provider

• Future directions of Next Generation HPC

Directions	Features
flexibility and scalability	• flexible response to varying simulation workloads, reducing job queue times and improving overall efficiency
Interactive workflow	• Support more interactive simulation environments, allowing for real-time adjustments and analysis
Minimize data transfer	• Streamline data transfer processes for pre, post-processing to minimize delays and improve workflow efficiency
Application support	• Expand support for a wider range of simulation applications to accommodate diverse user needs and workflows
Security and Control	• Maintain high levels of data security and control while leveraging the benefits of cloud-based HPC solutions



• Flexibility and scalability

 Microsoft Azure HPC virtual machines can scale to thousands of cores to meet various workload demands, with InfiniBand network support for high-performance, low-latency communication.

Interactive workflow

- Start dedicated HPC clusters using a GUI program without manual configuration as needed
- Connect to the head node using Remote Desktop and perform simulations from pre-processing to post-processing

• Minimize data transfer

- Input and result files are stored in each user's blob storage and shared to group blob storage

Broader application support

- Use virtual machine images with pre-installed simulation software available in the Azure marketplace.
- -Install your own applications on each HPC cluster as needed.

• Security and control HPC

- Data security and controls of HPC are preserved based on Azure RBAC (Role-Based Access Control)



NEXTFOAM NextHPC on Azure

• Launch HPC cluster using GUI and perform interactive simulation

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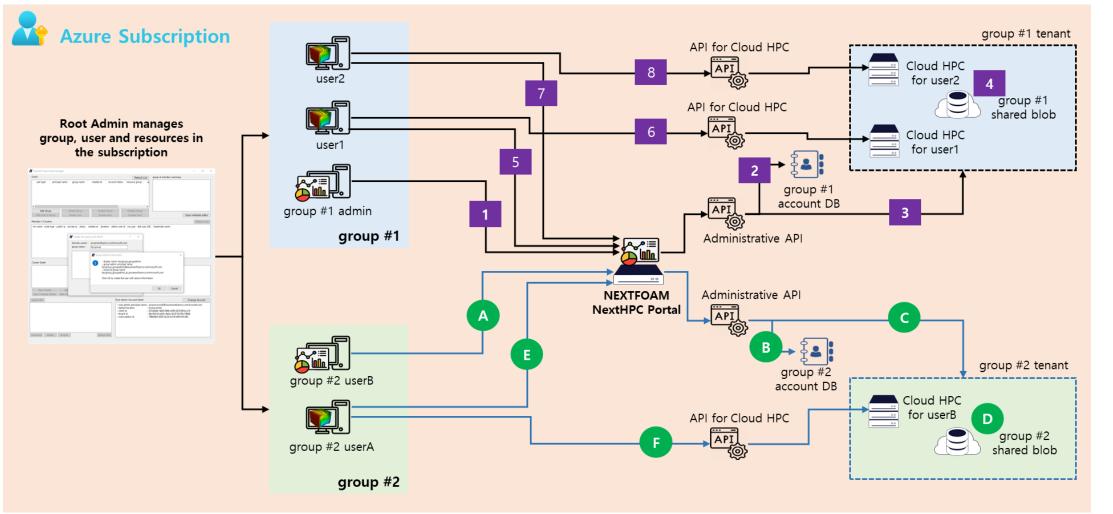
• Broader application support with Azure Marketplace images

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NEXTFOAM NextHPC on Azure

• Azure RBAC based data security and controls of HPC



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Concluding remarks

• Need for HPC in CAE Simulation

- Handles complex simulations with large data sets efficiently
- Speeds up computations, enabling faster design decisions
- Enhances accuracy through detailed and precise simulations
- Adapts to varying project demands, from small to extensive analyses
- Scales to meet growing computational needs

• Future Direction of Next Generation HPC

- Offers flexible responses to varying simulation workloads
- Supports interactive workflows for real-time adjustments
- Minimizes data transfer delays for improved efficiency
- Expands support for a wider range of simulation applications
- Maintains high levels of security and control in cloud environments



